

Climate change and the epithelial barrier theory in allergic diseases: A One Health approach to a green environment

The G20 under India's Presidency is guided by the motto "One Earth, One Family, One Future" and has an overwhelming emphasis on "Lifestyle for Environment (LiFE)". The G20-T20India-Task Force-3 (TF-3) on LiFE, Resilience and Values for Wellbeing has addressed and developed policy briefs and statements/recommendations addressing the climate crisis with the One Health approach among other aspects of climate adaptation.¹ The G20-T20India-TF3 has addressed sustainable consumption and production within the framework of circular economy and decarbonization of individual lifestyles, urban and rural infrastructure development, rural-urban balance, and nurturing traditional values and ethics. Implementation of the G20-T20India recommendations and monitoring of its progress is crucial to achieving the goals set forward.

The prevalence of allergic diseases including asthma, allergic rhinitis, atopic dermatitis, food allergies, and others has reached epidemic proportions and is a major global health concern. This steep increase suggests that environmental factors are taking a toll on our immune system.²⁻⁴ Epidemiological and experimental studies have demonstrated the relationship between various environmental factors and climate change on allergic diseases.⁵⁻⁷

Early reports from the 1960s and follow up studies indicated a starting timepoint for increasing prevalence of asthma, rhinitis, and atopic dermatitis in children.^{3,4,8-14} After the 2000s, a new wave of epidemics emerged starting from USA and influencing the western world, including food allergy and anaphylaxis, eosinophilic esophagitis, and drug-induced anaphylaxis.¹⁵⁻¹⁷ Similar to allergic diseases, the increase in autoimmune diseases, such as diabetes, rheumatoid arthritis, multiple sclerosis, and celiac disease, began in the 1960s, and this trend continues today in developing countries.^{4,18-22}

Environmental factors such as climate change including global warming caused by the accumulation of greenhouse gases from human activities, air pollution and reduced biodiversity are major threats to human health with detrimental effects on a variety of non-communicable diseases (NCDs)/lifestyle diseases including allergic diseases, which is the most prevalent of NCDs.^{6,7} During the coronavirus disease 2019 (COVID-19) pandemic reduced pollution from vehicle exhaust, albeit increased waste pollution from personal

protective equipment.²³ Climate change and global warming have contributed to rising sea levels, and more frequent extreme weather events such as heat waves, precipitation changes, wildfires, and desertification. These climate changes diminish the crop yields and reduce the nutritional value of the crop, thereby having a devastating toll on food security and causing, among others, zinc, iron, and protein deficiencies in the populations affected. The high atmospheric CO₂ levels promote the growth of allergenic pollen like ragweed.²⁴ Vulnerable and underserved populations such as children, pregnant women, individuals with comorbidities, the elderly, and indigenous people are particularly susceptible to diseases brought about by climate change.

G20 India: The 18th G20 Heads of State and Government Summit in New Delhi will take place on 9–10 September 2023. There will be a culmination of all the G20 processes and meetings held throughout the year among ministers, senior officials, and civil societies.

Think20 (T20): is an official Engagement Group of the G20. It serves as an "idea bank" for the G20 by bringing together think tanks and high-level experts to discuss policy issues relevant to the G20.

Task Force (TF)-3: LiFE, Resilience, and Values for Wellbeing is introduced by Prime Minister Modi at COP26, "Lifestyle for Environment (LiFE)" aims to entail a change in individual and societal behavior with respect to sustainable consumption and production. The taskforce emphasizes the need to create a mass movement for sustainable consumption, in which every citizen and stakeholder contributes to the green transition effort. It explores ways to ensure that capital and capacity is available to develop a disaster resilient infrastructure in island nations, developing countries, and for developing future cities and habitats.

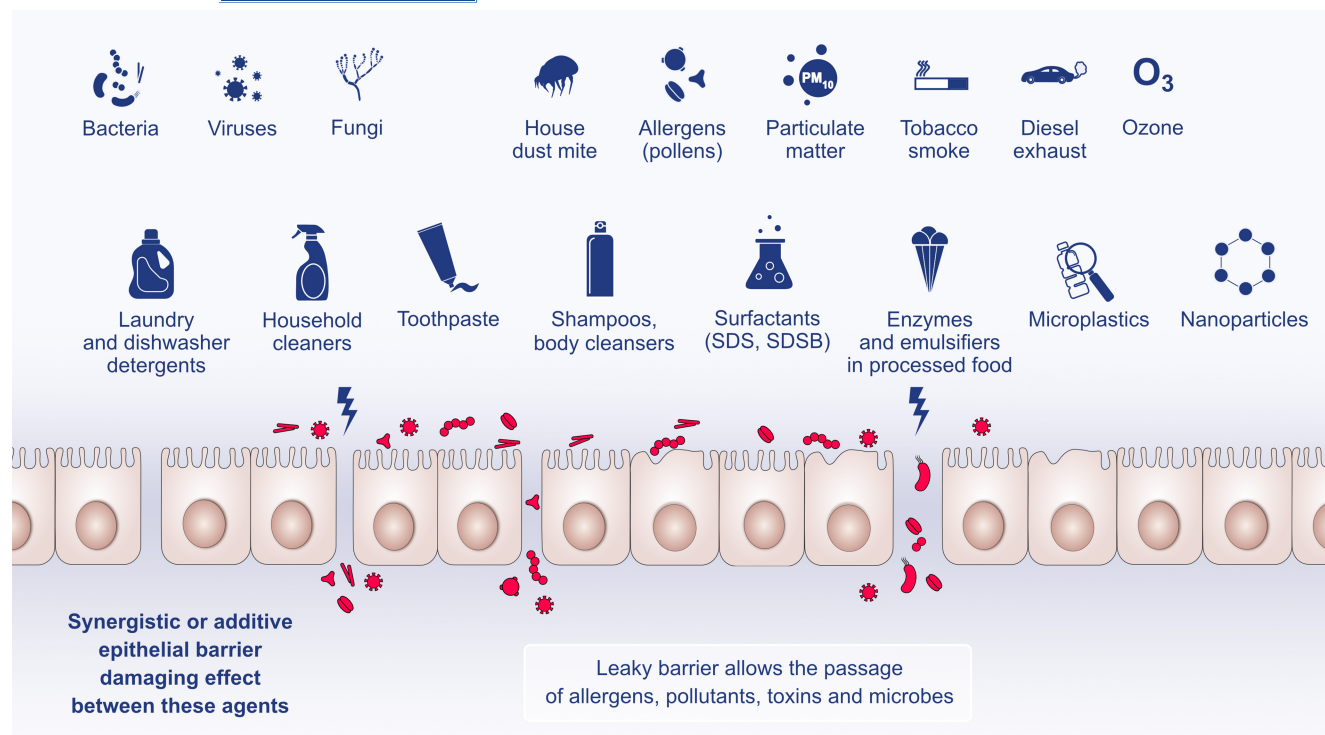


FIGURE 1 The increase in the prevalence and exacerbations of many allergic, autoimmune, metabolic and neurodegenerative diseases has been associated with damage to the epithelial layer induced by exposure to infectious agents, allergens, particulate matter, diesel exhaust, cigarette smoke, laundry and dishwasher detergents and rinse aids, household cleaners, toothpaste, shampoos, surfactants such as sodium lauryl sulphate in cleaning industry, microplastics, nanoparticles, ozone, processed food additives, emulsifiers and other unidentified chemical substances. Some of these substances may act synergistically in the damage of epithelial barriers. Leaky barriers allow the passage of allergens, pollutants, toxins and microbes, leading to dysbiosis, inflammation and hyperreactivity of the immune system.

The term “exposome” refers to all environmental factors individuals encounter throughout their lifetime,^{25–28} which can be categorized into three groups: the general external environment, the specific external environment, and the host-dependent internal environment. The general external environment includes factors such as climate, urban–rural settings, and education level, while the specific external environment comprises individual factors such as lifestyle choices, exposure to pollutants, and infectious diseases. The host-dependent internal environment encompasses both the biological effects of external exposure and biological responses, such as metabolism, inflammation, and oxidative stress.

The Epithelial Barrier Theory is a comprehensive explanation for the global, epidemic-level rise in chronic health conditions over the past 65 years. The theory proposes that industrialization and modernization have detrimentally impacted the human exposome enabling contact with toxic substances that disrupt the epithelial barriers of the skin, upper and lower airways, and gut mucosa. This disruption and entrance of detrimental substances to subepithelial areas triggered microbial dysbiosis and an inflammatory immune response that can initiate or aggravate many chronic inflammatory diseases (Figure 1).^{2,29,30} The surface of our skin, respiratory tract, and gut are all lined with protective cellular layers known as epithelial barriers. Intact epithelial barriers are crucial for homeostasis,

as they protect host tissues from infections, environmental toxins, pollutants, and allergens.^{31,32} A recent meta-analysis of 22 chemical inventories from 19 countries revealed that more than 350,000 new substances have been introduced to human lives since the 1960s, with little control over their toxicity.³³ Consequently, our human body is continuously exposed to a variety of potentially harmful substances, including particulate matter, diesel exhaust particles, cigarette smoke, nano- and microplastics, nanoparticles, ozone, NO, NO₂, CO, SO₂, toxic doses of surfactant containing household cleaners, laundry and dishwasher detergents, toothpastes, emulsifiers, preservatives in processed food, and pesticides.^{25–28,33–47}

Many of the chemical agents found in common consumer products (including toothpaste, shampoo, detergents, and processed foods), are known to damage these critical epithelial barriers in the respiratory and gastrointestinal tracts and skin, increasing permeability to bacteria, toxins, pollutants, and allergens^{25,28} (Figure 1). Particularly surfactants used in cleaning industry, such as sodium lauryl sulphate were shown to induce eosinophilic lung inflammation and eosinophilic esophagitis even when used alone in daily exposed doses in mouse models.^{48,49} When epithelial barriers are disrupted (or “leaky”), substances and microbes can inadvertently pass into deeper tissues, and trigger an immune/inflammatory response that can initiate or aggravate many chronic inflammatory diseases.^{2,27}

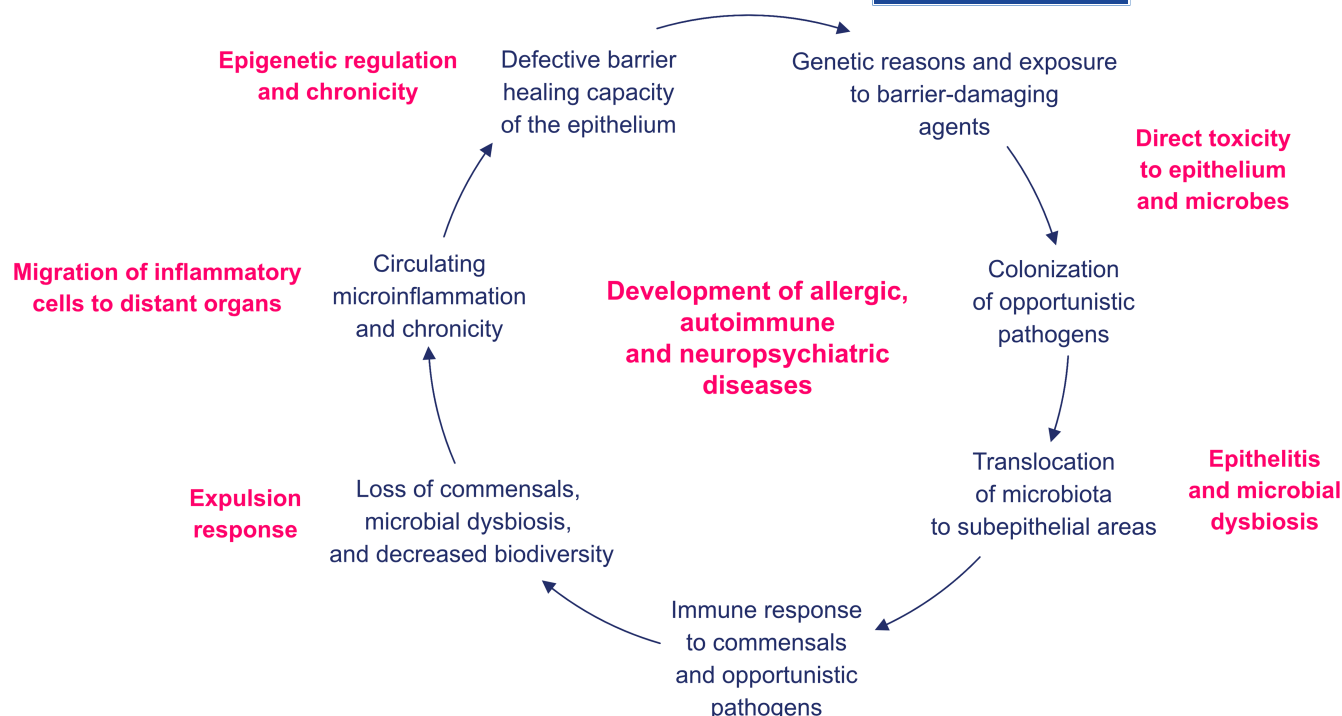


FIGURE 2 Pathogenetic events as mechanistic steps in the epithelial barrier theory: A cascade of events play a role in the pathogenesis of diseases associated with the epithelial barrier theory and the development of many chronic noncommunicable diseases. *Direct toxicity to epithelium and microbes*: Genetic defects in barrier-related molecules or exposure to epithelial barrier-damaging agents disrupt the skin and mucosal tight junction barriers and may also show direct toxicity to health-promoting commensal microbes. *Epithelitis and microbial dysbiosis*: Translocation of microbiota to inter- and subepithelial areas and colonization of opportunistic pathogens, such as *Staphylococcus aureus* (*S. aureus*), *Moraxella catarrhalis*, *Haemophilus influenzae* and pneumococcus bacteria. It is associated with microbial dysbiosis and decreased biodiversity of commensal bacteria. Epithelitis starts with the release of multiple alarmins. *Expulsion response*: An immune response develops towards commensals and opportunistic pathogens in the gut and respiratory system, and systemic inflammation takes place. Loss of commensals and colonizing opportunistic pathogens alter the microbial biodiversity. *Migration of inflammatory cells to distant organs*: Chronic inflammation in the subepithelial area prevails as one of the main reasons for the development of chronic diseases in affected tissues. Distant organs are affected due to circulating microinflammation and migration of activated immune system cells to distant organs. *Epigenetic regulation and chronicity*: An impaired ability to restore the epithelial barrier function due to inflammation and epigenetic changes instigates a vicious cycle of leaky barriers, microbial dysbiosis, and chronic inflammation.

A healthy microbiome on the surface of the mucosal barrier regulates numerous aspects of barrier homeostasis.⁵⁰ However, reduced biodiversity and alterations in the composition of gut and skin microbiota are associated with various inflammatory conditions, including asthma, allergic diseases, inflammatory bowel disease, type 1 diabetes, and obesity.⁵¹ Dysbiosis refers to an imbalance in the microorganisms residing in our tissues, with microbial dysbiosis and bacterial translocation being linked to the development and exacerbation of allergic and autoimmune diseases (Figure 2).⁵¹

Immediate action against climate change is warranted across all economic and societal sectors and at all levels. There is a need for governmental policies that mitigate fossil fuel usage, restore biodiversity, and reduce indoor and outdoor air pollution. Other mitigation efforts include improving the energy efficiency of buildings, creating infrastructure to allow people to use sustainable transportation, increase sustainable mobility, improving the energy efficiency of cars and buildings and reducing our exposure to toxic substances. There is a pressing need to educate the general population for climate

change and environmental cues for the importance of a healthy air, water, indoor and outdoor environment and food for the prevention of allergic diseases. The One Health approach addresses these issues in a multidisciplinary manner that stresses the interconnectedness between the health of humans, animals, and the environment (Figure 3).

The concept of planetary health directs attention to the extensive degradation of our planet due to anthropogenic activities. It focuses on sustainability by better balancing human needs with the preservation of the Earth's ecosystems in an effort to protect the health and well-being of future generations. To reverse planetary degradation and achieve sustainability and reduce the risk of potential disease outbreaks will call for a multidisciplinary, cross-sector, and transborder approach to change practices and policies at every level, from global to local.

KEYWORDS

chronic noncommunicable diseases, climate change, epithelial barriers, global warming, microbial biodiversity, one health

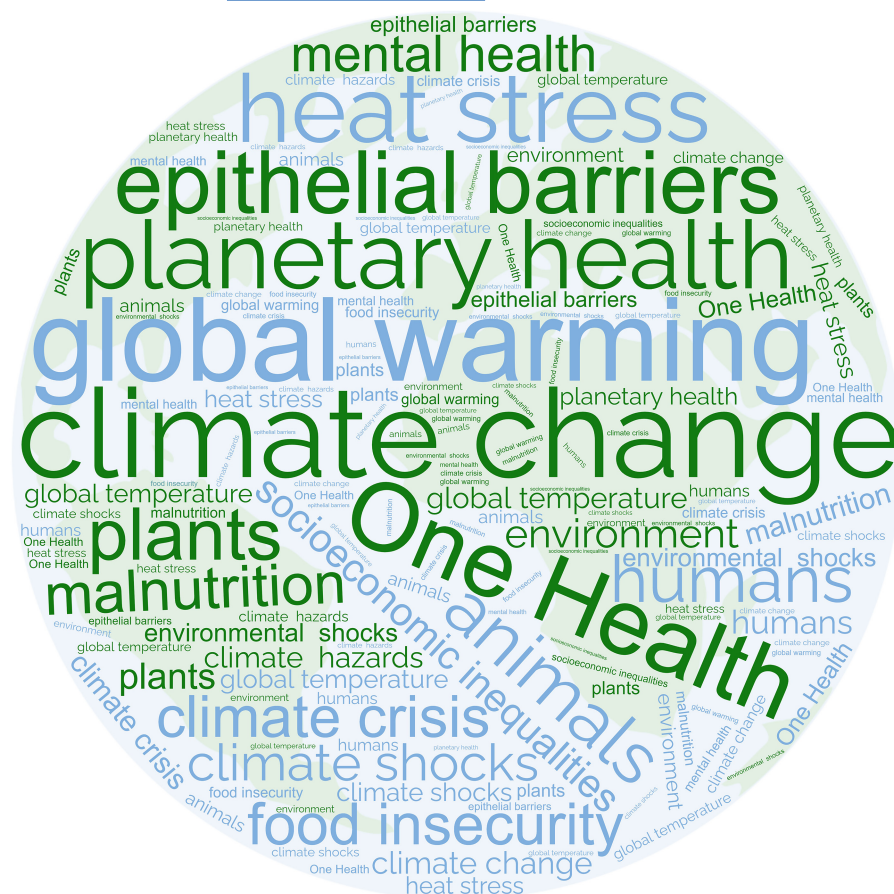


FIGURE 3 Word cloud with words related to Climate change and the One Health approach for allergic diseases.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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